IoT-Based Automatic Bed Vacancy Detection in Hospital

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Abstract-An efficient bed availability tracking system is necessary. In India, the availability of beds in hospitals is a big problem. Many times, people face issues related to the availability of many things. Whether it pertains to sleeping arrangements, seating options, or any other type of physical location, this has been perceived as a challenge by our team. This project aims to develop a system using IoT and the Web. That would be able to detect the availability of beds. It will not only be beneficial for the person who is looking for a bed but also for the hospital administration to manage and distribute it in a well-mannered way. The condition of bed availability in India is very poor. People look for treatment for many days. This situation in rural areas has even worsened, where many people die due to a lack of proper treatment and ignorance by the hospital. If they can book a bed from their place in advance, then it will be best for people and hospitals. And this is also beneficial for hospitals, as they can extend the beds for emergencies. We completed this project with the help of a sensor (an IR sensor) to detect the presence of a person, Arduino as the heart of the system, and different kinds of IoT devices.

Keywords: IoT Technology, Web Server, Arduino, Seat Vacancies, IR Sensors

I. INTRODUCTION

Nowadays, the Internet of Things (IoT) is a significant factor in modern human society. It is affecting every aspect of human life and its environment. [4] The digitization of the healthcare industry has significantly elevated its status as one of the top sectors. The convergence of the digital realm and Internet of Things (IOT) technologies yields a significant influence. The Internet of Things (IoT) refers to a system of interconnected physical devices that facilitate global communication and data exchange without the need for direct human intervention. The Internet of Things (IoT) employs a combination of electronic actuators, software, sensors, tools, and machines to facilitate the transfer of data from one location to another via the internet.

[2] The challenges are faced in locating unoccupied beds and decentralizing details of bed occupants in hospitals. There is not a single system in the market that is solving this problem at the administration level or at the public level. So, to solve these kinds of challenges, we are going to propose a system that will solve this problem at the administration level in hospitals and for normal humans at the public level. This research paper proposes to develop an IOT-based automatic bed vacancy detection system. That will help in solving the above-described problem. [3] During the pandemic of COVID-19, there was a lack of a system to verify the availability of beds equipped with the necessary infrastructure for the patients in question. This system is useful for normal days and in emergencies.

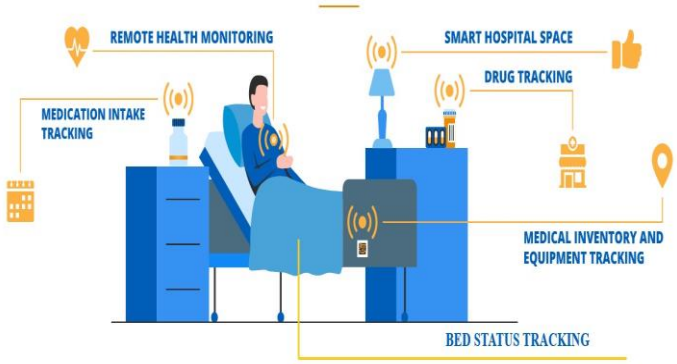

Fig. 1: IOT in Healthcare

This is an innovation towards making the smart city more advanced by solving this problem from the root level.

II. BACKGROUND

[4] Hardware Techniques: The topic of interest pertains to the hardware components utilized in the Internet of Things (IoT) ecosystem. These are used in a variety of gadgets, including sensors, microcontrollers, bridges, etc. The primary engine that allows Internet of Things (IoT) technology to operate in real time is physical devices. This device's capabilities include monitoring, analyzing, communicating, controlling, and, while converting an analog signal to a digital one, sensing its surroundings. Local storage on the devices houses all the gathered data, which can then be transferred to external storage, such as databases or third-party systems, utilizing the internet connection built into the device's board, switches, and chips.

[3] Sensor: It is a physical tool for detecting surrounding objects. It can recognize certain types of input and react to them to produce an output. Data is gathered and converted into a form that is electric in nature. Data that can be read by

humans is displayed as the output of the sensor's measured values. To further comprehend the sensor, let's look at an example. The use of infrared sensors allows automatic doors to identify objects.

Infrared Sensor: Infrared radiation is the most common form of electromagnetic radiation that comes from the electromagnetic spectrum and has a longer wavelength than visible microwaves. Simply put, less electricity was needed. Since it can detect radiation with a wavelength range of 8 to 14 m, it can realistically detect the human body. PIR sensors, also known as pyroelectric sensors or passive infrared radiation sensors, are employed as motion detectors. The motion's velocity, direction, displacement, acceleration, and time can all be calculated. Even in movement, it is more precise and effective. As needed by the user, the output is transformed into digital form. There are active and passive types of infrared sensors. Active infrared sensors may both emit and detect infrared light. The two elements that make up an active IR sensor are a light-emitting diode (LED) and a receiver. When something is near the sensor, the LED's infrared light that reflects off of it is picked up by the receiver. Active IR sensors are often used in the obstacle detection systems of robots as proximity sensors. PIR sensors do not produce infrared radiation themselves; they only detect it when it is there. An infrared filter that blocks out all other light wavelengths, a Fresnel lens that concentrates light from various angles into a single point, and a housing unit that shields the sensor from other environmental factors like humidity are all parts of passive infrared sensors.

LCD Display: A liquid-crystal display is a flat-panel display or other electronically controlled optical device that uses polarizers and the light-modulating properties of liquid crystals. Liquid crystals don't generate light directly; instead, they use a backlight or reflector to produce coloured or monochromatic images. The results of the IoT sensor would then be loaded on the LCD for display, depicting the vacancy at the lower level rather than showing it on the website. Because LCDs have a parallel interface, operating an LCD requires the microcontroller to simultaneously manage many interface pins. Where data is written to the LCD's memory is determined by a register select (RS) pin on the interface. You can decide between using the instruction register, which is where the LCD controller looks for instructions on what to do next, or the data register, which stores the content of the screen. Additionally, you have a choice of the writing mode, the enable pin, and the eight data pins (D0-D7), as well as the read/write (R/W) pin. The states of these pins (high or low) correspond to the corresponding operations when bits are written to or read from registers, respectively. [4]

[4] Software Module: In the Internet of Things, the software module's task is to collect data from the hardware devices. They function as a communication platform between IoT devices and centralized databases with the help of a data server. The values are slotted and transferred to boost the physical device's memory storage capacity and processing power. Operating a software module built with predefined IoT devices and languages like C, C#, Java, etc. allows for some necessary processes to be enabled and more effective purposes to be achieved.

[4] Arduino Programming: The Arduino Integrated Development Environment processes code written on various Arduino board circuit chips using the hardware programming language known as Arduino. Arduino disassembled the microcontroller into a more usable form. A new word for the Arduino program is Sketch. The setup function is automatically called when a sketch is launched to initialize an Arduino board. For practical use, most microcontrollers are made with Arduino boards.

[4] Database Module: Database refers to the component that organizes and stores the collected data. A data record or file that contains all the information about the data is often found in a computer database. All created data is saved in a structured manner with trustworthy links between rows and columns. In database management, read-only and write access to a user's data is always very convenient. when it is in a structured form. The relational database's information is simple to retrieve, alter, and modify. Pre-defined categories are put up in relational databases. Each collection of data is kept as a table with at least one column corresponding to the same category of rows. For application and user programs, it favors the Structured Query Language (SQL) interface. Without any additional restrictions, they can be easily expanded for the inclusion of new data and the modification of existing data.

III. Literature Survey

According to some surveys, there is work going on with similar systems in different sectors.

[11] For lasers, Shan He, Shilun Feng, and others have presented "IoT-Based Laser-Inscribed Sensors for Detection of Sulphate in Water Bodies" in their research paper. This study served as the basis for the interaction between the hospital's Wi-Fi and internet systems and the sensors. For the best situation, we have calculated the cost of laser-based sensors. The necessity of ports for connecting to the internet will be supported by this effort.

[10] The parameter(s) to be evaluated and checked when utilizing the laser-based sensor have been suggested by Gnath and colleagues in their paper titled "Designing and testing a laser-based vibratory sensor." This research also shed light on the applicability of these sensors. Our work on lasers' boundary conditions was influenced by these variables. These restrictions could be widened, and the bed tracking system could be strengthened in future studies.

One of the most important fields of research today is motion detection. In the presence of motion, many tasks are completed. The usage of the Arduino (UNO) microcontroller, ultrasonic sensor, passive infrared sensor, and many other devices to detect and measure distances has been one of the research's main areas of interest. The objective is to employ as little labour as possible while measuring and monitoring human behaviour remotely. The goal of this project was to create a sensor that can quickly determine how far an object is, track how those distances change as the object gets closer, and show the results on an LCD with a sound alert and a light-coded indicator.

[12] LIDAR has been discussed by Dekui LV, Xia Xin Yang, et al. in their paper titled "Research on the technology of LIDAR data processing." This document has been used in this work to better understand how LIDAR technology is employed in the medical industry. In this project, the sensor signal is controlled and sent to a web portal using an Arduino-based microcontroller.

Jinal Shah et al. (2018) utilized IoT in their paper titled "Smart Hospital Using IoT". In this paper, the authors extensively analyzed the usage and necessity of IoT technology to propose a system that combines sensor technology with the Internet of Things (IoT). They employed various sensors to measure different physiological details of a patient, such as heart rate, pressure, and temperature sensors. With this system, concerned authorities can remotely monitor a patient's health, the level of saline in the bottle, heartbeat, blood pressure, temperature, and control electricity from a distant location.

[5] The research aims to pioneer an innovative Android-based Remote Controlled hospital bed, integrating cutting-edge computer vision technology, and prioritizing energy efficiency. The bed is engineered to autonomously navigate along a designated track, proficiently surmounting obstacles aided by three ultrasonic sensors and two IR sensors for accurate obstacle detection and precise distance measurement.

TABLE. I. COMPARISON WITH OTHER PAPERS

Aspect	**IoT-Based Automatic Bed Vacancy Detection**	**Existing IoT-Based Systems in Medical Field**
Detection Method	Sensor	Various sensors (e.g., motion, pressure)
Purpose	Detect bed occupancy/vacancy in real-time	Monitor patient vital signs, activity, etc.
Application	Healthcare facilities	Hospitals, home healthcare, etc.
Primary Functionality	Bed occupancy monitoring	Patient monitoring and management(Manually)
Accuracy	High	Variable
Real-time Monitoring	Yes	Yes/No
Data Transmission	Wireless (e.g., Wi-Fi, Bluetooth)	Wireless and wired(e.g., Wi-Fi, Zigbee)
Cost	Moderate	High
Scalability	Scalable	Not Scalable
Installation and Maintenance	Complexity Low	Variable, depends on system complexity
Human Interference	No	Yes/No
Use Cases	Bed Management, Resource Allocation	Patient Monitoring

IV. METHODOLOGY

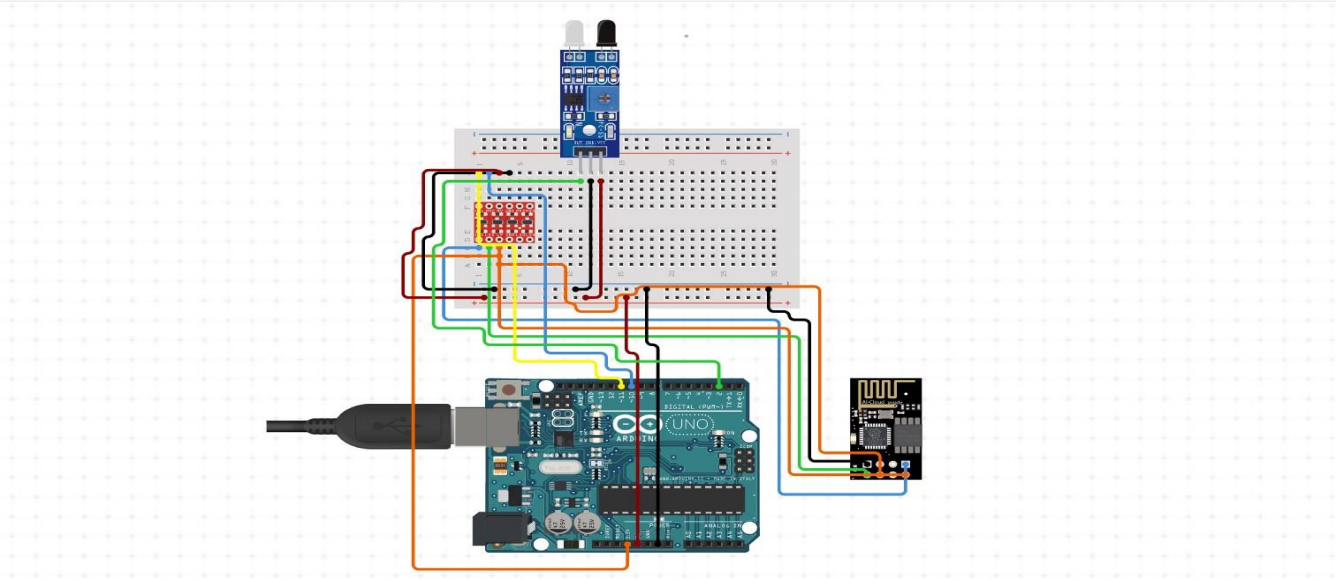

Fig. 2: Circuit diagram of the hardware model

It will come as a revolutionized system for the rural areas as they had to wait for a long time in search of bed but could find the bed. But this system will solve their problem in some way by locating a suitable location, a better hospital with an available bed. For this, we are going to use some kind of technology and tools, i.e., Arduino, IR sensors, LCD (to show the current counter of the filled status of beds out of the number of beds in a particular hospital), and a web interface (React is used to give the front end to the system).

1) IR sensors will identify the object using its property of object detection. An IR sensor can detect a person with its ability to detect IR radiation. It works with radar technology. The radiation comes towards the receiver end from the presence of the person, which will help in detecting the patient.

2) Then, after the object detection, there would be possible chances for the object to be detected or not. Here, that part also takes place, where the patient is out of bed for a certain threshold period, which would be counted as vacant after surpassing that time. To display the presence and altered frequency based on the patient's presence, we will also use an LCD for the prototype.

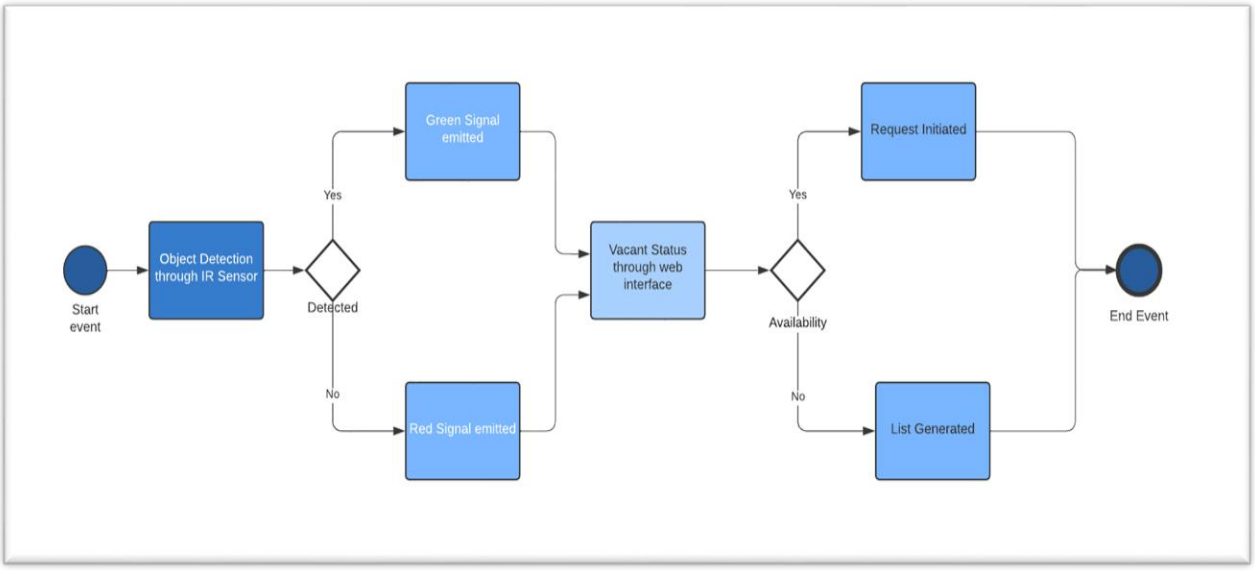

Fig. 3: Flow Chart of system

3) For the more enhanced user interface, there has been a significant attempt to provide this vacant status through the web interface. For enhanced systems, the Raspberry Pi will come into the picture, as will an IR sensor for detecting the presence of a person (the IR sensor will detect it through transmitted infrared (IR) rays and receiving the presence by the receiver end). The Raspberry Pi is usually used where a lot of complex operations are required. It can also communicate with several Arduinos since the Raspberry Pi works as a full-fledged microprocessor.

4) For transferring data from the sensor to the server, we are going to use a Bluetooth module, which will transfer the signals from the sensor to the server. Here, in the database, all the important information will be stored.

5) After receiving the data from the Wi-Fi module in JSON, webpage data will be changed dynamically with the help of the document object model. If a person is discharged from the hospital, then the bed is again available for people, and the status becomes 'Available' in green colour. If the patient occupies the bed, then that bed's status will be changed to 'Not Available' in red colour.

6) We will generate a list of additional hospitals where he can find beds if he wants to reserve a bed, but it is not available, meaning it is occupied by another patient. If all the hospitals are full, then the process of booking beds will end. If the bed is available again, then we send the information that the bed you are looking for is available so that he can perform that process again and get a confirmed bed. We will store the user data so that, with the help of nature-based prediction algorithms, we can predict the future traffic about bed booking and inform the hospital management so that they can prepare themselves.

Hospital

Beds	Status
Bed-1	(Avaliable)
Bed-2	(Avaliable)
Bed-3	(Avaliable)
Bed-4	(Avaliable)
Bed-5	(Avaliable)
Bed-6	(Avaliable)

Fig. 4(a): Availability Status

Hospital

Beds	Status
Bed-1	(Not Avaliable)
Bed-2	(Not Avaliable)
Bed-3	(Avaliable)
Bed-4	(Avaliable)
Bed-5	(Not Avaliable)
Bed-6	(Avaliable)

Fig. 4(b): Vacant Status and Filled Status

V. Result Analysis:

In our research, the role of Arduino is pivotal in enabling the seamless detection of object presence within the bed occupancy detection system. This microcontroller facilitates the integration of various sensors, particularly the IR sensor, allowing for efficient detection of occupancy status without the need for human intervention. Additionally, our system boasts a user-friendly web interface that displays real-time bed availability status, a feature absents in previous manual systems. By automating this process, we achieve a remarkable accuracy rate of over 90%, ensuring transparency in bed management operations.

Furthermore, our proposed system significantly reduces costs by 50-60% compared to traditional manual systems that rely on human intervention for bed status updates. This cost-saving advantage underscores the practicality and economic feasibility of our IoT-based solution in healthcare settings.

A distinctive feature of our system lies in its ability to automatically update bed availability data using WebRTC (Web Real-Time Communication) sockets. By leveraging this technology, the need for manual intervention is eliminated. If a predefined threshold time is exceeded, signalling potential bed vacancy or occupancy, the Arduino initiates the necessary updates, seamlessly reflecting the status change in the web interface. This automated process enhances the efficiency and reliability of our system, setting it apart from other existing solutions in terms of effectiveness and ease of use.

VI. Conclusion

The implementation of an IoT-based automatic bed vacancy detection system in hospitals promises to significantly enhance healthcare management. This project introduces a systematic facility management approach aimed at expediting bed and service bookings within hospital premises. Leveraging IR and ultrasonic sensors, in conjunction with a server and Raspberry Pi, this system operates at a comprehensive level. The IR sensors diligently monitor bed occupancy status, ensuring timely updates. Utilizing IoT modems, Raspberry Pi establishes connectivity with the server, which hosts an integrated database for data storage and facilitates device communication via a web application.

This innovative solution stands to revolutionize healthcare accessibility for the general populace. By enabling pre-booking of patient beds and necessary facilities through a user-friendly web application, both ambulance drivers and ordinary citizens gain the convenience of securing accommodations and treatment solutions before hospital arrival. Such proactive measures hold the potential to mitigate mortality rates stemming from bed scarcity and inadequate treatment provision. In essence, the proposed system heralds a paradigm shift towards proactive healthcare management, ultimately fostering improved patient outcomes and healthcare service delivery.

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